Energy Management at Taj Mahal Hotel, Mumbai

Prepared for **Taj Group of Hotels**
Mumbai

TERI Project Report No. 2002IE64

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Energy Management at Taj Mahal Hotel, Mumbai

Energy Analysis

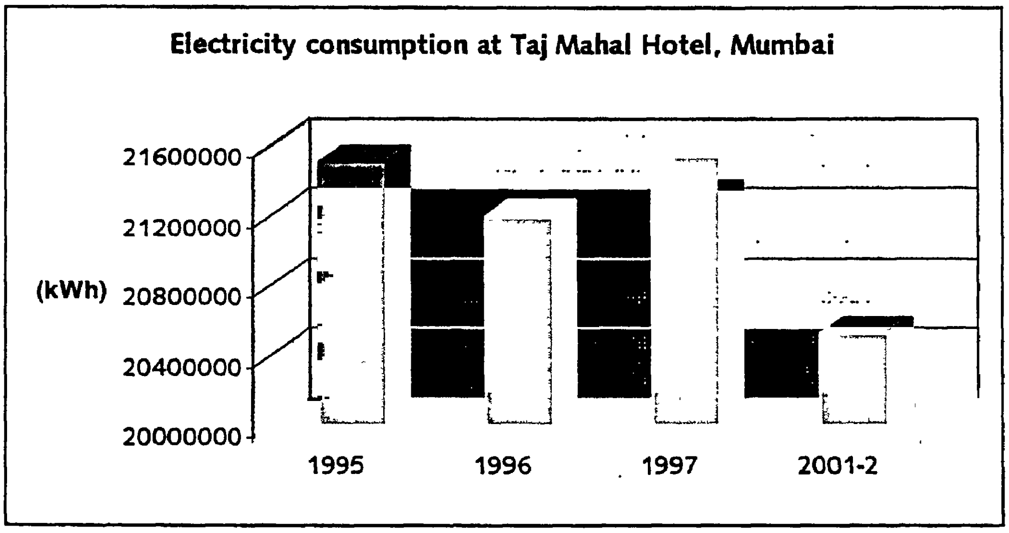
Energy Quantity

At Taj Mahal Hotel, main sources of energy are electricity which is used in lighting, air conditioning & refrigeration, pumps, kitchen, laundry, office equipment and other electrical appliances & fuel oil which is consumed in boiler for generating steam and hot water.

Consumption data of these sources are collected and given in tables below:

Table 1: Electricity consumption

Year	*kWh*
1995	21511000
1996	21199000
1997	21541000
2001-2	20529880



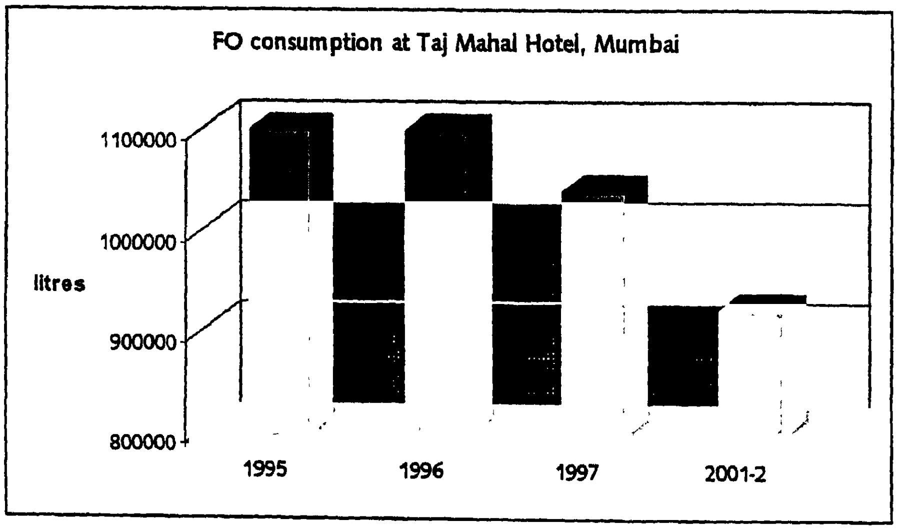
Observations

- As clearly shown above, a reduction of 4.1% has been achieved in 2001-02 as compared to the average annual electricity consumption till 1997.

- Electricity consumption which was approximately 58677 kWh/day till 1977, now it has dropped to around 56246 kWh/day or a daily reduction of 2431 units has been achieved at Taj Mahal Hotel due to implementation of various energy conservation measures and conscious operation of electrical equipment.

Table 2. Fuel Oil consumption

Year	*Liters*
1995	1099224
1996	1097994
1997	1038430
2001-2	921762



Observations

- As shown above, a reduction of 14.5% has been achieved in 2001-2 as compared to the average annual fuel oil consumption till 1997.
- Fuel oil consumption in boiler which was approximately 2955 litre/day till 1977, has reduced to around 2525 litre/day or a daily reduction of 430 litres has been achieved at Taj Mahal Hotel due to implementation of various energy conservation measures and conscious operation of boilers.

Energy cost

- In 1997 the electricity tariff was Rs 4.8/kWh which has increased to Rs 6.1.kWh now (approx. 27% hike).

- Approximately 32% hike has been witnessed in FO price. FO, which was Rs 9.2/litre in 1997, now costs Rs 12.1/litre.
- If no reduction would have been possible and the consumption remains the same as it was in1997, at present tariff approximately Rs 14.39 crores will have to be paid towards electricity & FO costs as compared to Rs 11.3 crores which was paid in 1997. However, due to reduction in electricity and FO consumption currently Rs 13.64 crores are being paid, an annual saving of Rs 76 lakhs is being achieved.

Air conditioning plants

The air-conditioning at Taj Mahal hotel is provided with the help of a centrally air conditioning system. The present total cooling capacity of the system is 2300 TR. Cooling is produced through one TRANE centrifugal chiller of 600 TR, four 300 TR Westing House centrifugal chillers each of 300 TR capacity and one 500 TR Hitachi vapour absorption machine. Presently only electric chillers are being used and VAM is lying redundant.

Energy conservation measure implemented

Two Westing House each of 300 TR have been replaced recently with two Dunham Bush screw chillers each of 300 TR rating.

Expected energy and cost savings

Since it was an internal decision of Taj Management, no saving prediction reports was found. However, based on the recorded & measured data an attempt is made to estimate the saving potential and given in following section.

Total electricity consumption of Trane plant	:	2469908 kWh/yr
Total number of operating hours of Trane plant	:	7975 hrs/yr
Average operating load on Trane plant	:	309 kW/hr
Full load rated efficiency of the plant	:	0.63 kW/TR
Average operating efficiency of the plant	:	0.60 kW/TR

Since operating efficiency of the plant is extremely good hence, it is assumed that Trane plant will continue to run as it is running now.

Total electricity consumption of WH plants	:	1721977 kWh/yr
Total number of operating hours of Trane plants	:	11252 hrs/yr

Average loading on Trane plants	:	153 kW/hr (each plant)
Full load rated efficiency of the plant	:	0.675 kW/TR
Average operating efficiency of the plant	:	0.70 kW/TR

Since two Westing House plants have been replaced by two Dunham Bush plants, they will operate for those hours for which Westing House plants were operating. Also the operating efficiency of new plants will match (0.60 kW/TR) with Trane plant, they may also replace Trane plant whenever required but that will not save any energy.

It is also recommended that instead of operating VAM operate two Dunham Bush plants.

Total number of hours two Westing house plants operate	:	9002 hrs/yr
Total number of hours VAM operate	:	758 hrs/yr
Total number of hours Dunham Bush plants are going to operate	:	10518 hrs/yr
Potential of energy saving due to Dunham Bush plants	:	231396 kWh/yr
Total saving in energy cost	:	Approx. 14 lakhs
Total energy consumption in plants	:	4191885 kWh/yr
Reduction in plant consumption due to Dunham Bush plants	:	approx. 6%

Condenser water pumps

Implemented energy conservation measure

The three 100 hp old condenser water pumps have been replaced with three new generation high efficiency pumps each of 75 hp. Also variable frequency drive has been installed on each pump to adjust the flow as per the number of plants operating. Right now the drives are set to operate at frequencies ranging between 35 to 46 Hz.

Projected energy and cost savings

At the time of implementation detailed study was carried out on how and at what frequency pumps will be operating. A scheduled was assumed and energy and cost savings were predicted on that basis as shown in table below.

Table 3: Operating schedule and kW of CDW pumps

Operating Time	*Nos of operating new pumps*	*Operating kW of new pumps*	*Operating kW of old pumps*
12 am to 4 am	1	35	56
4 am to 8 am	1	45	56
8 am to 12 pm	2	70	112
12 pm to 4 pm	2	90	112
4 pm to 8 pm	2	80	112
8 pm to 12 am	1	45	56

Energy consumption of new CDW pumps on a typical day	:	1460 kWh/day
Energy consumption of old CDW pumps on a typical day	:	2016 kWh/day
Daily energy saving	:	556 kWh
Total energy saving in a year	:	202940 kWh
Total saving in energy cost in a year	:	Rs 1238000
Total project cost	:	Rs 1755000
Simple pay back period	:	18 months

Remarks

The efficient pumps with variable water flow in condenser line have potential to save around 27.5% energy which is otherwise consumed in condenser pumps with a payback period of one and half years.

Cooling Towers

Initially four cooling towers were installed at Taj Mahal hotel and their average energy consumption was 13.4 kW/tower. If we assume that all the four towers were operating 24 hrs and round the year:

Initial energy consumed in cooling towers : 13.4×4×24×365 = 463930 kWh

Energy conservation measures implemented

Since aluminium blade fans consume more energy as compared to FRP blades fans, Taj Management decided to replace aluminium blade with FRP blades in existing cooling towers, which they got it replaced later. The manufacturer predicted that with this replacement the consumption per cooling tower would reduce to 8.83 kW per tower.

Projected consumption with FRP blades : 8.83×4×24×365 = 309400 kWh
Projected energy saving per year : 154530 kWh or 33.3 %.

With addition of some extra load, two more cooling towers were added and at present six cooling towers are operational. Variable frequency drives have been installed on cooling tower no-2 & no-4. They sense the entering cooling tower temperature and adjust the fan speed accordingly.

Present energy consumption & savings achieved

Measurement were carried out on all the cooling towers and fan input kW was measured at different hour are given below:

Operating time	*CT-1*	*CT-2*	*CT-3*	*CT-4*	*CT-5*	*CT-6*	*Total*
12 AM to 4 AM	15.6	1.28	5.43	1.25			23.56
4 AM to 8 AM	15.6	3.6	5.43	3.57			28.2
8 AM to 12 PM	15.6	4.68	5.43	4.6			30.31
12 PM to 4 PM	15.6	7.2	5.43	7.0	6.5	6.5	48.23
4 PM to 8 PM	15.6	7.2	5.43	7.0	6.5	6.5	48.23
8 PM to 12 AM	15.6	4.68	5.43	4.6			30.31
						Total	**208.84**

Present energy consumption in CTs	:	208.84×4×365 = 304910 kWh
Realised energy savings	:	463930 – 304910 = 159020 kWh
Annual saving in energy cost	:	Rs 970000

Remark

By implementing two energy conservation measures (mainly replacing aluminium blades with FRP blades and by installing variable frequency drives on two cooling towers) Taj Mahal hotel is saving approximately 159020 kWh or 34% of the initial energy consumption in cooling towers in spite of that two more cooling towers have been added. This leads to a cost saving of Rs 970000 annually.

Chilled water system

At present existing AC system uses a constant chilled water system for space conditioning. It has also been realised that since the hotel cooling load does not remain constant and it varies with time depending on the room occupancy, functions and restaurant timings. Last time when energy audit was conducted it was found that converting constant chilled water flow system to variable chilled water flow system would be a major energy saving options. Hotel engineering staff is also very keen to get it done but they are not very confident how this can be done. They have various doubts in mind specially how to balance two different type of return lines (old wing is on direct return and new wing is having reverse return) and also bypass line will be designed and balancing valve would be sized. Controlling of secondary chilled water pump through pressure transducer is another thing that seems to be bit difficult to them. However, it appears that in spite of above doubts converting constant chilled water flow into variable chilled water flow is a feasible and economical energy saving option. We recommend Taj Management to take help of some outside consultant who have sufficient designing & retrofitting experience of variable chilled water flow system. He should be advised to study and analyse the existing chilled water system and redesign it for variable system. His help should also be taken during implementation stage.

Remark

The above energy conservation measure was suggested when energy audit was conducted last but not yet implemented. On an average at present daily plant and chilled water pump consumption is approximately 16792 kWh, conversion of constant chilled water flow to variable would save around 2300 kWh daily which amounts to 14% of the energy consumed in plants & chilled water pumps or Rs 5121000 annually. As estimated earlier the project will require an initial investment of Rs 50 lakhs.

Suggested action

Implement it at the earliest.

Air Handling Units

Suggested Measure

In last energy audit it was found that there exists a potential to save energy in air handling units fans. Mostly all the fans used to operate at constant speed irrespective of fluctuations in area. Hence it was suggested to install open loop frequency drive to run fans at different speed depending on the load. The major areas where this option was found economical feasible were Chamber lounge, Lobby, TFA north top & bottom, TFA south top & bottom, TFA seaside & north side, NH electrical & Crystal central south & north.

Observation

It was observed during present visit that however, few frequency drives especially in function halls have been installed and Taj Management plans to install few more in near future.

Suggested action

Expedite the installation of frequency drives on remaining AHUs as suggested in last study. As estimated earlier there exists a potential to save approximately 190000 kWh or Rs 10 lakhs at an initial investment of Rs 20 lakhs.

Exhaust and fresh air systems

Suggested energy conservation measure

During last study it was recommended to install open loop frequency drives on various exhaust fans & fresh air fans and schedule them to run at different slower speeds when load is less. Areas included are Shamiayana exhaust & fresh air, Roof top kitchen exhaust, Main kitchen fresh air, Chamber's support area fresh air, LP1 shaft fresh air, Tanjore kitchen fresh air and steward fresh air.

Observations

Till now open loop frequency drives have only been installed on air handling units fans, but during visit we were informed by the engineering staff that they are planning to install VFDs also on main kitchen exhausts. The air quantity which is being supplied or exhausted by different exhaust and fresh air fans were measured in given in the last report. In main kitchen the air quantity supplied by fresh air fan is more than what is being exhausted by the exhaust fans making kitchen to operate at positive pressure. VFD installation on exhaust fans will further reduce the air quantity, which is being exhausted. No doubt it will save some energy but it will reduce the level of thermal comfort maintained in main kitchen. However, installation of VFD on fresh air fan not only saves energy but also improve the comfort level in main kitchen. Keeping this mind VFDs should be installed on above suggested areas otherwise it will change the airflow pattern in the area in consideration and add to the discomfort.

Recommended action

Start installing open loop frequency drives on suggested areas. There exists a potential to save approximately 40800 kWh or Rs 2.5 lakhs annually. This will also require an initial investment of Rs 4.2 lakhs

Lighting systems

Implemented energy conservation measures

Less efficient incandescent lamps have been replaced in guest corridors, pantry, staircase, and guest. These replacement would save approximately 54000 kWh or Rs 330000 annually.

Recommended actions

In our last energy audit we have found out a series of energy conservation measures for lighting systems and they are given below.

Public areas

Ball room

Replace 60 W GLS, which are used to illuminate the pillars by 11 W CFLs. Replace the 60 W GLS in side-wall mounted bracket lights by 15 W CFL. Also replace the 15 W GLS used to illuminate the stage by 36 W high efficiency tubelights (about 10 would be required) with high frequency electronic chokes. The TLs should be of colour temperature of 2700° K.

Option 1. Replacement of incandescent lamps by CFLs

Assumed operational hours	8 hours
Reduction in connected load	4.016 kW
Total energy saving/year	11727 kWh/year
Savings in energy cost	Rs 56300/year
Required initial investment	Rs 30800
Payback period	6 -7 months

Option 2. Replace 15 W GLS used for stage lighting by 36 W high efficiency TLs and high frequency electronic chokes

Assumed operational hours	8 hours
Reduction in connected load	1.285 kW
Total energy saving/year	3752 kWh/year
Savings in energy cost	Rs 18000/year
Required initial investment	Rs 5050
Payback period	3 months

Apollo bar

The Apollo bar, located on the top floor of the 18-storeyed hotel building, is daylit from two directions. It was observed that all lights of the bar (excepting a few which were located above the side aisles) are kept on throughout the day at full voltage. At night all the lights (except those in the bar counter and in the parallelopiped luminaires) are kept at 180 V. Considering the fact that all the lights are dimmed during night-time, and that there is ample daylight during day time, all the 60 W GLS lamps except the ones at the bar counter could be replaced by 40 W GLS and not dimmed at all. This would reduce 20 W/lamp operation during daytime when lights are on at full voltage. Also in the bar store area, it is recommended to replace 60 W GLS by 15 W CFL lamps.

Option 1. Replace 60 W GLS in downlighters (excepting bar counter lights) by 40 W GLS

Assumed operational hours	13 hours
Saving in Kw	2.18 kW
Total energy savings, assuming 6 hours operation at 230V during	4775 kWh/year
Savings in energy cost	Rs 23000/year
Required initial investment	Rs 1090
Payback period	Negligible

Option 2. Replace 60 W GLS in bar counter area by 15 W CFLs

Assumed operational hours	13 hours
Saving in kW	0.252 kW
Total energy savings	1195 kWh/year
Savings in energy cost	Rs 5740/year
Required initial investment	Rs 2100
Payback period	4 months

Option 3. Replace 18 W TL provided below bar counters by 11 W CFLs

Assumed operational hours	13 hours
Saving in kW	0.076
Total energy savings	360 kWh/year
Savings in energy cost	Rs 1730/year
Required initial investment	Rs 1400
Payback period	8 months

Harbour bar

This area does not use dimmers for controlling light output from the lights. It is proposed to replace the incandescent bulbs of the bracket lights and the table lamps by CFLs of equivalent wattage. Also GLS is used for diffused lighting from behind the seats. Here it could be replaced by 36 W TLs and high frequency chokes.

Option 1. Replace 60 W GLS in table lamps and bracket lamps by 15 W CFLs

Assumed operational hours	14.5 hours
Savings in kW	0.504 kW
Total energy savings	2667 kWh/year
Savings in energy cost	Rs 12800/year
Required initial investment	Rs 4200
Payback period	4 months

Option 2. Replace the incandescent bulb behind seats by 36 W TLs and light frequency chokes (approximately 10 numbers TLs would be required)

Assumed operational hours	13 hours
Savings in kW	0.955 kW
Total energy savings	5054 kWh/year
Savings in energy cost	Rs 24260/year
Required initial investment	Rs 5050
Payback period	2.5 months

Golden room

This room amply daylit and yet all the lights are on during preparation and setting up. It is proposed to use day-linked sensors to cut off lights when not required during daytime. Results show that it is possible to save 25% of present energy consumption by installation of such sensors.

Option 1. Use daylight linking sensor

Assumed operational hours	8 hours
Total energy savings, assuming that 25% of present energy use can be	1095 kWh/year
Savings in energy cost	Rs 5250/year
Required initial investment	Rs 8000
Payback period	1.5 years

Banquet toilets

The 60 W GLS bulbs which are used in downlighters in the banquet toilets are proposed to be replaced by 15 W CFLs. In addition, it is proposed to use ultrasonic sensors for the toilets to switch off lights when the restrooms are not occupied.

Option 1. Replace 60W GLS in down lighters by 15W CFLs

Assumed operational hours	12 hours
Savings in kW	1.05 kW
Total energy savings	4600 kWh/year
Savings in energy cost	Rs 22075/year
Required initial investment	Rs 8750
Payback period	4.5 months

Option 2. Install ultrasonic occupancy sensors for banquet toilets

Assumed operational hours	12 hours
Total energy savings (assuming that incandescent bulbs in downlighters are replaced by CFLs)	2048 kWh/year
Savings in energy cost	Rs 9828/year
Required initial investment	Rs 15600
Payback period	1.5 years

Sea lounge

The Sea Lounge has three sections and during the survey it was mentioned that the occupancy in the middle section is low due to poor illumination. It is proposed to increase the luminaires in the section, to change over from diffuser type of luminaires to transparent luminaires, and to change the colour of walls and ceiling to a lighter colour which has a higher co-efficient of reflection.

Also, it was observed that there is ample daylight in the section, which is nearest to the window. Yet all lights were kept on during daytime. Hence the lights for this section could be connected to a time switch and lights could be kept off for at least 4 hours/day. The GLS bulbs used for table lamps and behind seats could be replaced by CFLs of equivalent wattages.

Option 1. User timers for daylit section of the restaurant

Assumed number of hours for which lights could be	4 hours/day
Total energy savings	1390 kWh/year
Savings in energy cost	Rs 6670/year
Required initial investment	Rs 2200
Payback period	4 months

Option 2. Replace GLS lamps from behind seats, and in table lamps by 9 W CFLs and 15 W CFLs respectively

Assumed operational hours	15 hours
Savings in kW	0.284 kW
Total energy savings	1555 kWh/year
Savings in energy cost	Rs 7460/year
Required initial investment	Rs 4900
Payback period	4 months to 2 years

Banquet office and banquet manager

In the banquet office, the ceiling lights that are 60 W GLS in transluscent covers could be replaced by 15 W CFLs. It was observed that in the banquet manager's office, the lights were kept on even if the room was unoccupied. It is proposed to use infrared occupancy sensors in this room to minimize wastage.

Option 1. Replace 60 W GLS in downlighters with transluscent covers by 15 W CFLs

Assumed operational	12 hours
Savings in kW	0.336
Total energy savings	Rs 1470 kWh/year
Savings in energy cost	Rs 7060/year
Required initial investment	Rs 2800
Payback period	4.5 months

Option 2. Install occupancy sensors in banquet manager's office

Assumed operational hours	12 hours
Assumed savings over present	25%
Total energy savings	553 kWh/year
Savings in energy cost	Rs 2650/year
Required initial investment	Rs 3000
Payback period	2 years

Banquet store

The banquet store has two sections – lower and upper. It is proposed to use infrared occupancy sensors for the upper section of the store which is sparingly used but where the lights are always kept on. Also the magnetic chokes of the TLs are proposed to be replaced by high frequency electronic chokes.

Option 1. Install infrared occupancy sensors in upper section of store

Assumed operational hours	15 hours
Energy savings (25% of present	291 kWh
Savings in energy cost	Rs 1400
Required initial investment	Rs 3600
Payback period	2.5 years

Option 2: Replace magnetic chokes by HF electronic chokes

Assumed operational hours	15 hours
Energy savings	1595 kWh/year
Savings in energy cost	Rs 7650
Required initial investment	Rs 5530
Payback period	7 months

Lobby toilets

Replace the 60 W GLS in downlighters and in the hanging chandeliers by 15 W CFLs and use ultrasonic sensors in each of the toilets.

Option 1. Replace 60W GLS in downlighters and hanging chandeliers by 15 W CFLs

Assumed operational	24 hours
Savings in kW	2.142 kW
Total energy savings	18760 kWh/year
Savings in energy cost	Rs 90048
Required initial investment	Rs 17850
Payback period	2.5 months

Option 2. Use ultrasonic sensors for restrooms

Assumed operational hours	24 hours
Total energy savings (assuming 25% saving over final energy consumption after replacement by CFLs)	3550 kWh/year
Savings in energy cost	Rs 17050/year
Required initial investment	Rs 15600
Payback period	11 months

Business centre

Option 1. Use ultrasonic sensors in toilets

Assumed operational hours	16 hours
Total energy savings	438 kWh/year
Savings in energy cost	Rs 2100
Required initial investment	Rs 7800
Payback period	3 years and 8 months

Corridor of executive offices

Option 1. Replace 60 W GLS by 15 W CFLs

Assumed operational hours	12 hours
Saving in kW	0.42 kW
Total energy savings	1840 kWh/year
Savings in energy cost	Rs 8830

Required initial investment	Rs 3500
Payback period	4.5 months

Chambers

Replace 60 W GLS in chambers office, toilets, downlighters of chambers lounge (where not dimmed) and of lobby by 15 W CFLs. Also use ultrasonic sensors for chambers toilet.

Option 1. Replace 60 W GLS in chambers office, toilets, down lighters of chambers lounge (where it is not dimmed) and of chamber's lobby by 15 W CFLs

Assumed operational hours	6-16 hours (varied)
Saving in kW	4.97 kW
Total energy savings	17124 kWh
Savings in energy cost	Rs 82195
Required initial investment	Rs 27300
Payback period	3.5 - 7 months

Option 2. Use ultrasonic sensors in chambers toilet

Assumed operational hours	8 hours
Total energy savings	376 kWh/year
Savings in energy cost	Rs 1800/year
Required initial investment	Rs 15600
Payback period	8½ months

Restroom (with shopping arcade of new wing)

Replace 60 W GLS in downlighters by 15 W CFLs and use ultrasonic sensors in restrooms.

Option 1. Replace 60 W GLS in downlighters by 15 W CFLs

Assumed operational hours	14 hours
Saving in kW	0.882 kW
Total energy savings	4507 kWh/year
Savings in energy cost	Rs 21600
Required initial investment	Rs 7350
Payback period	4 months

Option 2. Use ultrasonic sensors in restrooms

Assumed operational hours	14 hours
Total energy savings	428 kWh/year
Savings in energy cost	Rs 2300
Required initial investment	Rs 15600
Payback period	6.½ years

Shamiana

Option 1. Replace 60 W GLS in downlighters by 15 W CFLs

Assumed operational hours	18 hours
Savings in kW	0.214 kW
Total energy savings	1380 kWh/year

Savings in energy cost	Rs 6600
Required initial investment	Rs 1750
Payback period	4 months

Lobby

Option: Replacement of GLS by CFLs has already been done in most of the fixtures in the lobby. However similar replacements can be made in all the remaining downlighters which are about 52 in number.

Option 1.

Assumed operational hours	24 hours
Savings in kW	2.184 kW
Total energy savings	19130 kWh/year
Savings in energy cost	Rs 91830
Required initial investment	Rs 18200
Payback period	2.5 months

Guest area

Corridors of new wing

Corridors of the new wing are mostly illuminated by 36 W TL and high frequency electronic chokes. It is proposed to step down voltage to 200 V using Beblec P-20 system. In three floors, the lighting scheme comprises of 60 W GLS in downlighters and chandeliers. There it is proposed to replace the 60 W GLS bulbs in downlighters by 15 W CFLs.

Option 1. Use Beblec P-20 system to step down voltage of Tls to 200 V

Assumed operational hours	12 hours
Saving in kW	11.466kW
Total energy savings	50,220 kWh
Savings in energy cost	Rs 241000
Required initial investment	Rs 104000
Payback period	5 months

Option 2. Use 15 W CFLs in downlighters in three corridors

Assumed operational hours	12 hours
Saving in kW	1.134 kW
Total energy savings	1655 kWh/year
Savings in energy cost	Rs 7950
Required initial investment	Rs 3150
Payback period	4.5 months

New wing rooms (306 rooms)

Use key tag switch for energizing room circuits. Use infrared sensors (with manual override) for guest toilets. Use 15W CFLs in place of 60W GLS in guest toilets.

Option 1. Use 15 W CFLs in guest toilets

Assumed operational hours	8 hours/day
Assumed occupancy rate	90%
Saving in kW	90 kW
Total energy savings	236425 kWh/year
Savings in energy cost	Rs 1134842
Required initial investment	Rs 749700
Payback period	7 months

Option 2. Use key tag switches for guestrooms and infrared sensors (PIR sensing) for guest toilets

Assumed operational hours	8 hours/day
Assumed occupancy rate	90%
Total energy saved	117811 kWh
Savings in energy cost	Rs 565490
Investment for key tag	Rs 489600
Investment for infra-red	Rs 918000
Payback period	2.5 years

Service corridor

Use corridor/stair sensors to switch off lights when not occupied and change copper chokes to high frequency chokes.

Option 1. Use high frequency chokes in place of copper chokes

Assumed operational hours	8 hours
Saving in kW	2 kW
Total energy saved	5807 kWh/year
Savings in energy cost	Rs 27877
Required initial investment	Rs 60435
Payback period	2 years

Guest elevator of old wing

Option 1. Replace 60 W GLS by 15 W CFLs

Assumed operational hours	24 hours
Saving in kW	1.134
Total energy savings	9933 kWh/year
Savings in energy cost	Rs 47680
Required initial investment	Rs 9450
Payback period	2.5 months

Old wing rooms (312 rooms)

Use key tag switch for energizing room circuits. Use infra-red sensors (with manual override) for guest toilets. Use 15W CFLs in place of 60W GLS in guest toilets.

Option 1. Use 15 W CFLs in guest toilets

Assumed operational	8 hours
Assumed occupancy	90%
Saving in kW	52.416 kW
Savings in energy	137750 kWh
Savings in energy cost	Rs 661196
Required initial investment	Rs 436800
Payback period	7.5 months

Option 2. Use key tag switches and infrared occupancy sensors for toilets

Assumption	EMS installed in club rooms
Assumed operational hours	1.134
Assumed occupancy	90%
Savings in energy	76933 kWh
Savings in energy cost	Rs 369279
Initial investment	Rs 275200 (key tag sensors) + Rs 436800 (infra-red sensors)

Suite rooms

Use key tag switch for energizing room circuits. Use infrared sensors (with manual override) for guest toilets. Use 15W CFLs in place of 60W GLS in guest toilets.

Option 1. Use 15 W CFLs in guest toilets in place of 60 W GLS

Assumed operational	8 hours
Assumed occupancy	90%
Savings in kW	18.144
Total energy saved	47682 kWh/year
Savings in energy cost	Rs 228875
Initial investment	Rs 151200
Payback period	7 months

Option 2. Use key tag switches and infrared occupancy sensors for guest toilets

Assumed operational hours	8 hours
Assumed occupancy rate	90%
Total energy savings	69442 kWh/year
Savings in energy cost	Rs 333322
Investment in key tag sensors	Rs 76800
Investment in infrared sensors	Rs 144000

Lift landings and stairway lights for old wing

Option 1. Replace 60 W GLS in downlighters and in translucent luminaires by 15 W CFLs

Assumed operational hours	24 hours
Savings in kW	0.924 kW
Total energy savings	8094 kWh
Savings in energy cost	Rs 38852
Initial investment	Rs 7700
Payback period	2.5 months

Option 2. Use daylight-linked sensors to switch off lights during daytime, or use timers to switch off lights for a fixed time

Assumed operational hours	24 hours
Total energy savings	8795 kWh/year
Savings in energy cost	Rs 42216
Initial investment	Rs 48000
Payback period	1 year and 1

Service areas

Car Parking

Option 1: Use high frequency chokes for TLs

Assumed operational hours	24 hours
Savings in kW	0.845 kW
Total energy savings	7400 kWh
Savings in energy cost	Rs 35525
Initial investment	Rs 23905
Payback period	8 months

Guest lift lobby adjacent to parking

Option 1: Replace 40 W GLS by 11 W CFLs

Assumed operational hours	24 hours
Savings in kW	0.26 kW
Total energy savings	2277 kWh
Savings in energy cost	Rs 10932
Initial investment	Rs 3500
Payback period	3.5 months

Second basement and maintenance areas

Replace copper bound chokes by high frequency chokes wherever replacements are not made and use 36 W high efficiency TLs and Beblec P-20 system to step down voltage to 200 V.

Option 1. Replace magnetic chokes by high frequency chokes

Assumed operational hours	24 hours
Savings in kW	0.78 kW
Total energy savings	6832 kWh
Savings in energy cost	Rs 32797
Initial investment	Rs 23700
Payback period	7 months

Option 2. Use 36 W high efficacy TLs and Beblec P-20 system to operate the TLs at 200 V

Assumed operational hours	24 hours
Savings in kW	1.323 kW
Total energy savings	11590 kWh
Savings in energy cost	Rs 55630
Initial investment	Rs 29170
Payback period	6 months

Service passages adjacent to kitchen

The service passages adjacent to kitchen were observed to have over 200 lux of illumination level. Here it is proposed to remove one TL/fixture.

Option 1. Remove one tubelight/fixture

Assumed operational hours	9 hours
Savings in kW	2.318 kW
Savings in energy	7614 kWh/year
Savings in energy cost	Rs 36547

Chambers Kitchen

Option 1. Use 36W high efficiency tubelights and Beblec P-20 system to step down voltage to 200V

Assumed operational hours	16 hours
Savings in kW	0.324 kW
Total energy savings	1892 kWh
Savings in energy cost	Rs 9082
Initial investment	Rs 16960 (Rs 13,000 for beblec P-20 and Rs 3960 for high efficiency TLs)

Butchery, gardemanger and bakery

Option 1. Use 36W high efficiency tubelights and Beblec P-20 system to step down voltage to 200V

Assumed operational hours	17.5 to 24 hours
Savings in kW	1.098 kW
Total energy savings	8423 kWh
Savings in energy cost	Rs 40430
Initial investment	Rs 13420 (for TLs) + Beblec system common to chamber's kitchen

Chef Offices

Option 1. Use infrared occupancy sensors to switch off lights when not required

Assumed operational hours	9-16 hours
Total energy savings	739 kWh
Savings in energy cost	Rs 3546
Initial investment	Rs 6000

Main kitchen

Option 1. Use 36W high efficiency TL and Beblec P-20 system to step down voltage to 200V

Assumed operational hours	24 hours
Savings in kW	0.576
Total energy saved	5045 kWh
Savings in energy cost	Rs 24219
Initial investment	Rs 7040 (for TLs) + Rs 6500 (for beblec system)
Payback period	7 months

Room service kitchen

Option 1. Use 36W high efficiency TL and Beblec P-20 system to step down voltage to 200V

Assumed operational hours	24 hours
Savings in kW	0.648 kW
Total energy saved	5676 kWh/year
Savings in energy cost	Rs 27247
Initial investment	Rs 7920 + Rs 6500
Payback period	7 months

Banquet passage

Option 1. Use 36W high efficiency TL and Beblec P-20 system to step down voltage to 200V

Assumed operational hours	12 hours
Savings in kW	0.324 kW
Total energy saved	1412 kWh
Savings in energy cost	Rs 6811
Initial investment	Rs 3960 + Rs 4600
Payback period	1 year and months

Steward department

Option 1. Use 15W CFLs in place of 60W GLS in downlighters

Assumed operational hours	24 hours
Savings in kW	0.168 kW
Total energy savings	1472 kWh/year
Savings in energy cost	Rs 7065
Initial investment	Rs 1400
Payback period	2.5 months

Golden dragon kitchen

Option 1. Use 36W, high efficiency TLs and Beblec P-20 system to operate the TLs at 200V

Assumed operational hours	16 hours
Savings in kW	0.234 kW
Total energy savings	1367 kWh
Savings in energy cost	Rs 6560
Initial investment for TLs	Rs 2860
Payback period	1 year and 1 month

Tanjore kitchen

Option 1. Use 36W high efficiency TLs and beblec P-20 system to operate the TLs at 200V

Assumed operational hours	16 hours
Savings in kW	0.219
Total energy savings	1261 kWh
Savings in energy cost	Rs 6054
Initial investment for TLs	Rs 2640
Payback period	1 year and 2 months

Service corridor in basement

Option 1. Use 36W high efficiency TLs and Beblec P-20 system to operate the TLs at 200V

Assumed operational hours	24 hours
Savings in kW	0.219 kW
Total energy savings	1892 kWh
Savings in energy cost	Rs 9082
Initial investment for TLS	Rs 2640
Payback period	10 months

Lockers

Option 1. Use 36W high efficiency TLs and beblec system to step down voltage to 200V

Assumed operational hours	24 hours
Savings in kW	0.756 kW
Total energy savings	6622 kWh
Savings in energy cost	Rs 31788
Initial investment for TLs	Rs 9240
Payback period	7 months

Beverage store

Option 1. Use 36W high efficiency TLs and Beblec P-20 system to operate the TLs at 200V.

Assumed operational hours	9 hours
Savings in kW	0.108
Total energy savings	355 kWh
Savings in energy cost	Rs 1703
Initial Investment	Rs 1320 (for TLs) + Rs 4600 (for Beblec system)
Payback period	3.5 years

Ancillaries

Option: The ancillary area comprises of the remaining corridors and back office areas in the basement and ground floor.

Here also it is proposed to use 36W high efficiency TLs and Beblec P-20 system to be operated at 200V.

Option 1.

Assumed operational hours	9 hours
Savings in kW	0.558 kW
Total energy saved	1833 kWh/year
Savings in energy cost	Rs 8798
Initial investment	Rs 6820 (for TLs) + Rs 6500 (for beblec P-20 system)
Payback period	1.5 years

Self-learning centre

The self-learning centre was observed to have all lights on even when the room was unoccupied. Here also it is proposed to use 36W high efficiency TLs and beblec P-20 system to operate the TLs at 200V. Also it is proposed to use ultrasonic sensors to switch off lights when the rooms are unoccupied.

Option 1. Use 36W high efficiency TLs and beblec P-20 system to step down voltage to 200V.

Assumed operational hours	9 hours
Savings in kW	0.42 kW
Total energy saved	1183 kWh
Savings in energy cost	Rs 5677
Initial investment	Rs 4400 (for TLs) + Rs 4600 (for beblec P-20 system)
Payback period	1.5 years

Option 2. Use ultrasonic sensors for SLC

Assumed operational hours	9 hours
Total energy savings	953 kWh
Savings in energy cost	Rs 4572
Initial investment	Rs 7800
Payback period	1 year and 9 months

Housekeeping

Linen Room

Option 1. Use 36W high efficiency TLs and beblec P-20 system to step down voltage to 200V

Assumed operational hours	11 hours
Savings in kW	0396 kW
Total energy savings	1590 kWh
Savings in energy cost	Rs 7630
Initial investment	Rs 4840 (for TLs) + Rs 6500 (for beblec P-20 system)
Payback period	1.5 years

Shamiana Kitchen, Room Service Kitchen, Zodiac Grill Kitchen

Use 36W high efficiency TLs and beblec P-20 system to step down voltage to 200V.

Shamiana kitchen

Assumed operational hours	24 hours
Savings in kW	0.594
Total energy savings	5203 kWh
Savings in energy cost	Rs 24976
Initial investment	Rs 7260 + Rs 6500
Payback period	6 months

Room service kitchen

Assumed operational hours	12 hours
Savings in kW	0.648
Total energy savings	2838 kWh
Savings in energy cost	Rs 13623
Initial investment	Rs 7920 + Rs 6500
Payback period	1 year

Zodiac grill kitchen

Assumed operational hours	16 hours
Savings in kW	0.36
Total energy savings	2102 kWh
Savings in energy cost	Rs 10091
Initial investment	Rs 4400 + Rs 4600
Payback period	11 months

Sea Lounge kitchen

Option 1. Use 36W high efficiency TLs, high frequency chokes and Beblec P-20 system to reduce voltage to 200V

Assumed operational hours	17 hours
Savings in kW	0.499 kW
Total energy savings	3115 kWh
Savings in energy cost	Rs 14952
Initial investment	Rs 7270 (TLs + chokes) + Rs 4600 (beblec system)
Payback period	9.5 months

Laundry

Option 1. Use 36W high efficiency TL and Beblec P-20 system to reduce voltage to 200V

Assumed operational hours	24 hours
Savings in kW	0.918 kW
Total energy savings	8042 kWh
Savings in energy cost	Rs 38600
Initial investment	Rs 11220 (for TLs) + 9500 (for Beblec P-20 system)
Payback period	6.5 months

Staff cafeteria

Option 1. Replace the 60W GLS by 15W CFLs and also replace the downlighting fixtures by reflector type of fixtures

Assumed operational hours	10 hours
Savings in kW	5.04 kW
Total energy savings	18396 kWh
Savings in energy cost	Rs 88300
Initial investment	Rs 42000
Payback period	6 months

Personnel manager's office

Option. Replace 60W GLS in personnel manager's room with 15W CFLs.

Assumed operational hours	12 hours
Saving in kW	0.294 kW
Total energy savings	1287 kWh/year
Savings in energy cost	Rs 6180
Required initial investment	Rs 2450
Payback period	4.5 months

The above-mentioned energy conservation measures will have potential to save around 880000 kWh (24% of the present consumption) or Rs 54 lakhs annually. The total investment required would be approximately Rs 60 lakhs.

Pumping systems

Implemented energy conservation measure

Two 7.5 hp high head pumps, which circulate the normal water, have been installed and previous constant flow has been converted to variable flow with the help of variable frequency drives. The projected saving is around Rs 9 lakhs and the project cost was approximately Rs 7.5 lakhs.

Observations

Taj Mahal management is planning to replace many existing low efficiency pumps with new generation high and variable flow pumps. However the focus is on the hot water circulation pumps. VAN engineering of Pune has carried out a study and submitted a proposal for enhancing energy efficiency in hot water system and save energy since this system operates round the clock. They have suggested a modification in existing hydropneumatic system both for LP & HP areas and convert them into variable flow system. The projected energy savings will be around Rs 10 lakhs but this would also require and initial investment of Rs 20 lakhs.

Remark

We very strongly recommend the implementation of this energy saving option in pumping system